Resource Action: EWG – 15A **Task Force Recommendation Category** 2

CHINOOK SALMON SPAWNING SEASON FLOW INCREASES TO REDUCE CHINOOK SALMON REDD SUPERIMPOSITION

Date of Field Evaluation: None

Field Evaluation Team: None

Proposed PM&E:
Incrementally increase flows in the low flow channel from relatively low flows (for example, 400-600 cfs or 600-800 cfs) to relatively high flows (for example, 800-1000 cfs or 1000-1200 cfs) throughout the Chinook salmon spawning season (for example, Sept 1 – Dec 1 or Sept 1 - Dec 15) in order change the lateral spawning habitat distribution from center of river channel during the early portion of the spawning season to margins of river channel in the later portion of the spawning season. Flows would be increased by some relatively consistent interval each week (for example, 25, 50, or 75 cfs/week) in order to increase usable spawning habitat and reduce superimposition of Chinook salmon redds. Once flows reach the high flow target, the high flow target would be maintained through May 30 in order to avoid dewatering Chinook salmon and steelhead redds through the incubation period for both species.

Potential Environmental Benefits:
- Increased quantity of Chinook salmon spawning habitat;
- Increased quality of Chinook salmon spawning habitat;
- Reduced redd superimposition of Chinook salmon redds; and
- Decreased Chinook salmon egg mortality

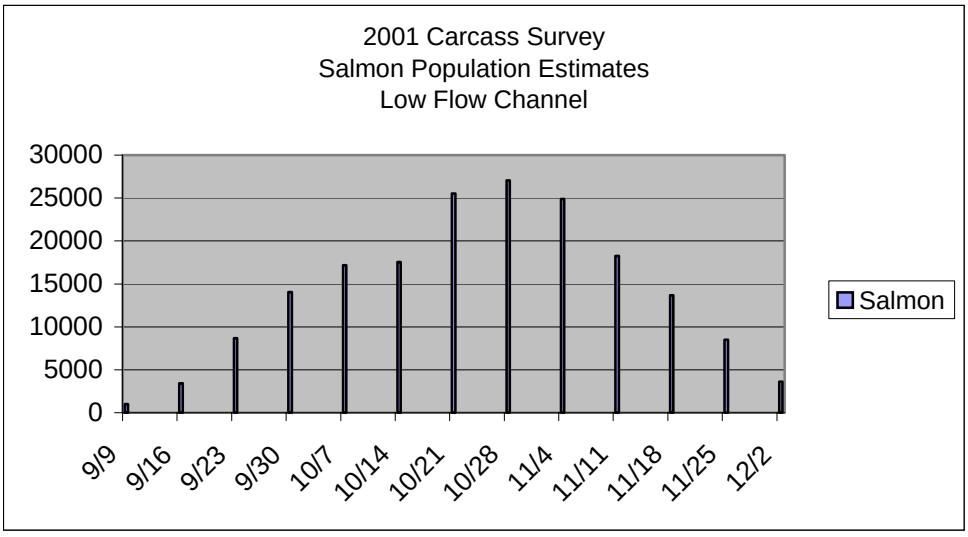
Conditions in the Proposed PM&E Implementation Area:
The low flow channel is heavily utilized by spawning adult Chinook salmon. Of the Chinook salmon spawning that occurs between the Fish Barrier Dam and Honcut Creek, approximately one-third occurs in the High Flow Channel, while approximately two-thirds occur in the Low Flow Channel. The intensive utilization of spawning habitat in the Low Flow Channel by adult Chinook salmon spawners results in redd superimposition, and is sufficiently intensive to prevent identification of individual redds in much of this reach of the Feather River. Historical study results suggest that superimposition reduces egg survival and egg survival is thought to be reduced in the Low Flow Channel as a result of redd superimposition.

A superimposition index was calculated for the low flow channel and high flow channel in 1995. In 1995, CDFG estimated the number of adult Chinook salmon spawners in the low flow channel at 44,111 and in the high flow channel at 15,572. In 1995, the total spawning area was estimated in the low flow channel was estimated at 773,732

square feet and in the high flow channel, the total spawning area was estimated at 915,289 square feet. Using Bell's estimate of 55 square feet for the surface area of an average sized Chinook salmon redd, the superimposition index can be calculated using the following formula: superimposition index = [(escapement * 0.5) * 55ft^2]/ total spawning area. For 1995, the calculated superimposition index was 1.57 in the low flow channel and 0.47 in the high flow channel. As a result, the focus of this proposed resource action is to increase the quantity of spawning habitat by altering later spawning habitat distribution in the low flow channel only.

Chinook salmon spawning occurs in the Low Flow Channel from September – December, see Figure 1 below. The graph shows the temporal distribution of spawning from the carcass survey. The number of spawning Chinook salmon is not evenly temporally distributed, with peak spawning activity occurring in approximately mid-October through mid-November.

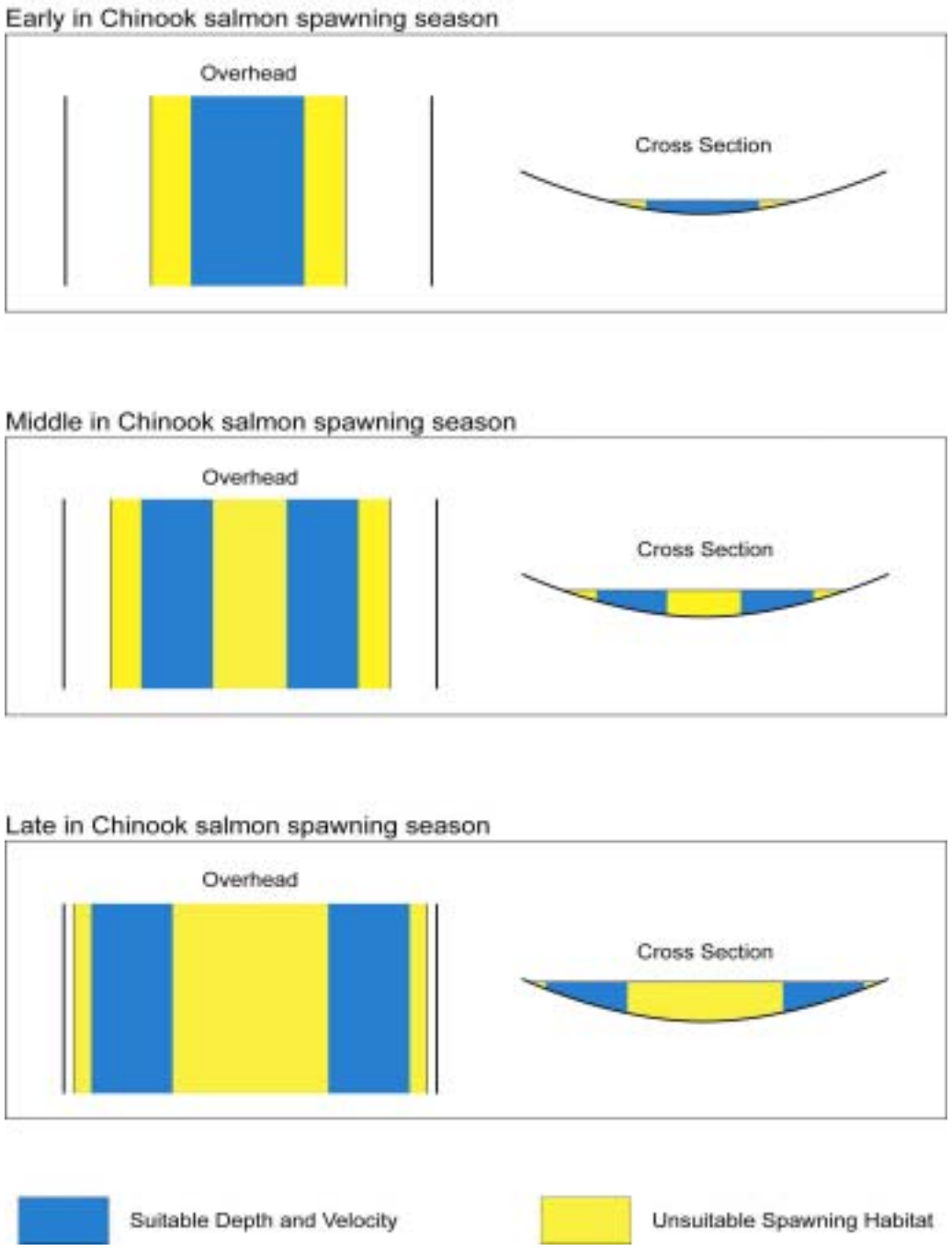
Figure 1: 2001 Carcass Survey Salmon Population Estimates - Low Flow Channel



Design Considerations and Evaluation:

Low flows (for example, 400-600 cfs or 600-800 cfs) during early part of the spawning season would require early Chinook salmon spawners to utilize the center portion of the river for spawning habitat. Increasing flows (for example, to 800-1000 cfs or 1000-1200 cfs) incrementally over the spawning season by some relatively consistent interval each week (for example, by 25, 50, or 75 cfs/week) in the later portions of the spawning season would encourage later spawners to utilize suitable spawning habitat on the margins of the river. Altering the location of the margin of the river within the river channel over the course of the spawning season may alter the lateral distribution of spawning over the season, resulting in decreased redd superimposition.

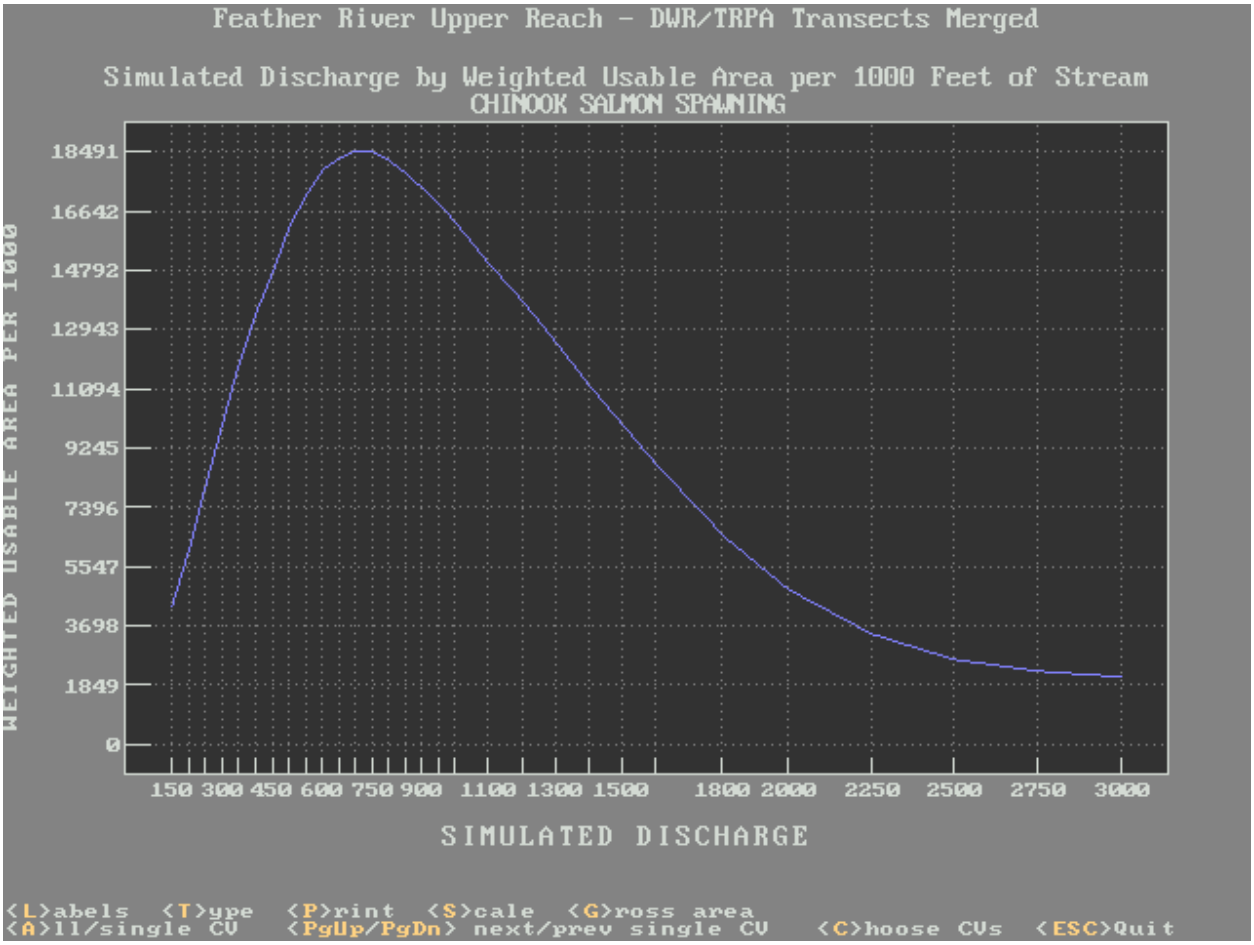
Figure 2: Conceptual Representation of Spawning Habitat



Any proposed flow regime that manipulates the amount of spawning habitat should take into account the number and temporal distribution of Chinook salmon spawners and the amount of habitat required for spawning at any given time throughout the spawning season. The peak of spawning activity in the Low Flow Channel occurs in approximately mid-October through mid-November and represents the portion of the spawning season with the highest amount of competition for spawning habitat. The proposed flow regime should incorporate the objective to provide the maximum amount of suitable habitat at the peak of spawning activity.

The PHABSIM model produced as part of Phase 2 of SP-F16 is an appropriate tool to evaluate some of the essential questions regarding whether the proposed flow prescription will likely result in successful manipulation of the lateral distribution of spawning habitat in the low flow channel. These questions include: 1) would low flow targets provide adequate spawning habitat for early spawners; 2) how much spawning habitat would be created (and lost due to water velocity spawning habitat constraints) for each increment of flow increase; 3) how much total spawning habitat would be created by implementing the proposed flow regime; 4) would the proposed flow manipulation result in changes to the lateral distribution of spawning habitat; and 5) if PHABSIM output is used to estimate the changes in lateral spawning distribution as a result of the proposed flow changes, do calculations of the redd superimposition index using the model output suggest that the proposed change in flows would reduce overall superimposition of Chinook salmon redds?

Figure 3: Preliminary SP-F16 Phase 2 Results - Low Flow Channel Chinook Salmon Spawning Weighted Usable Area Index



Although the specific analyses of the PHABSIM output on the response of Chinook salmon spawning habitat lateral distribution have not been conducted, the preliminary draft of the Chinook salmon spawning habitat weighted usable area are available, see Figure 3 above.

The range of appropriate low and high flows for developing this flow prescription should also take into account the projected quantity and quality of resulting spawning habitat at those flows. The PHABSIM output should be able to aid in determining logical low flow targets for consideration in this flow prescription by illustrating the habitat availability over a range of flows. The PHABSIM provides an index of the amount of available habitat. An analysis of the actual amount of habitat required to support the early season spawners as well as consideration of potential temperature impacts of low flows early in the spawning season, would need to be evaluated before a definitive flow target could be recommended. The model also could provide velocity information for higher flows to determine the upper range of velocities to consider. This upper range should not be so

high that it would scour spawning riffles, yet should be high enough to result in less favorable conditions for Chinook salmon spawning in the middle of the channel, where redds were constructed during lower flows. Spawning depth and lateral redd distribution could be monitored as part of the adaptive management program to determine the success of manipulating the lateral distribution of spawning habitat and fish behavioral responses to the conditions created.

Another design consideration would be the potential effect of the late spawning season/sustained flow targets on the quality and quantity of steelhead spawning habitat. As demonstrated by the Chinook salmon spawning WUA graph in Figure 3, the amount of habitat can be reduced at higher flows. Any flow recommendation for this PM&E would also need to evaluate if the prescribed flows provided an adequate amount of steelhead spawning habitat. A WUA for steelhead is not currently available and it has not been investigated yet if one could be generated from existing information (there may not be an adequate number of steelhead spawning observations available). The number of steelhead spawners in the Feather River is not currently known or documented. Relicensing study plan results are not expected to provide quantitative documentation of the number of steelhead spawners.

Other critical evaluation components for the development of the flow prescription include: modeling temperature impacts of flows below current flow regime on downstream water temperatures during the early portion of the Chinook salmon spawning season. The ability to comply with the water temperature requirement of 65°F at Robinson Riffle may be affected if flows lower than 600 cfs are chosen as the low flow requirement early in the spawning season. This potential impact could be modeled by the E&O water temperature model (WQRRS). If lower flows would result in difficulty complying with the Robinson Riffle water temperature requirement, this could potentially be resolved by utilizing colder water releases from Lake Oroville. Hatchery water temperature constraints may limit the ability to use colder water from Oroville reservoir as September 1 – 30 water temperatures may currently be no colder than 48°F and October 1 – November 30 water temperatures are required to be no colder than 47°F per the DFG 1983 operating agreement. If the hatchery water temperature requirements constrain the ability to achieve water temperature compliance requirements at Robinson Riffle at lower flows during the early portion of the Chinook salmon spawning season, the hatchery could potentially be provided with a separate water supply. A separate hatchery water supply proposed PM&E would require its own set of investigations.

Evaluating this proposed PM&E will require comparison against EWG-15B, a PM&E with a similar mechanism and framework, but slightly different overall resource goals. EWG-15B suggests providing a low flow for the first part of the Chinook salmon season and maintaining that low flow until spring-run Chinook salmon spawning is believed to be complete. Then, flows would be increased to the target high flow range. While EWG-15A also utilizes flow increase to alter the lateral distribution of spawning, it

suggests weekly incremental flow increases throughout the Chinook salmon spawning season in order to achieve the same high flow target as EWG-15B by the end of the spawning season.

The strategy proposed in EWG-15B is simpler operationally but relies upon a higher degree of confidence regarding the temporal distribution of the spring-run Chinook salmon spawners, which may be variable from year to year. Additionally, EWG-15B is designed specifically to benefit spring-run Chinook salmon to the extent possible. The strategy proposed in EWG-15A would be slightly more operationally complex to execute, but would reduce potential water temperature compliance issues and would not be susceptible to the variability in run timing. However, EWG-15A is designed to benefit all Chinook salmon spawners equally from the change in lateral spawning distribution, including those Chinook salmon spawning at the middle and end of the spawning period. Any proposed flow prescription designed to achieve this resource objective should be treated as an adaptive management program that would be managed and improved based on monitoring and continued evaluations.

Recommendations:
This proposed resource action has the potential to improve the problem (although not quantified in its severity or relative importance to the species' success) of superimposition of Chinook salmon redds associated with intensive utilization of spawning habitat in the low flow channel. Further information detailing the likely response of adult spawners to flow changes (primarily from SP-F16) would be needed to aid in determining the low and high flow targets before a definitive flow management prescription could be developed. An adaptive management approach to any flow prescription is recommended in combination with a redd distribution monitoring program to characterize the fish spawning habitat utilization in response to flow changes.

If this PM&E is to be developed to the next level of definition, additional information anticipated that would be required to develop a recommended flow prescription for an adaptive management program would include: 1) Areal extent of total spawning area delineated from aerial photographs - SP-G2: reportedly digitized but not yet delivered; 2) WUA: for spawning Chinook salmon (and steelhead?) - SP-F16: July 2003; 3) redd superimposition index calculation - SP-F10 Task 2B: Jan 2004, 4) carcass survey data: SP-F10 Task 2B: final report Jan 2004.

If the proposed action were to be evaluated for flows of 400 cfs ramping to a 1000 cfs flow from September 1 – May 30 (protective of steelhead incubation), this action would require a net increase of approximately 160,000 acre feet released through the low flow channel which would have an approximate annual power generation opportunity cost of $XXX - $XXX.

The Fisheries Task Force recommendation - Category 2 Waiting (F16 PHABSIM model results – August 2003)

Resource Action: EWG-17	**Task Force Recommendation Category:** 4
Resource Action: EWG-51	**Task Force Recommendation Category:** 4

PM&E Evaluation Team: Richard Harris (comments received from Koll Buer, John Cannon, David Olson and Phil Unger)

Proposed PM&E:
EWG-17 and EWG-51 are essentially the same Resource Action (PM&E), and therefore, are being presented together. The proposed Resource Action would "Enhance riparian vegetation and trees along banks for shading and increased habitat complexity." Locations for the proposed Resource Action are not specified except as follows: "One location for vegetation enhancement could be 'trailer park riffle', although high-water events may require continued maintenance and/or improvement."

EWG-17 and EWG-51 have been interpreted to mean undertaking plantings or other vegetation management to improve riparian vegetation conditions at specific sites. The criteria for selecting sites have not been defined but might focus on the ability to improve habitat for rearing salmonids.

Related PM&Es:
There are a number of Resource Actions that are either similar to or potentially complementary to this PM&E. They include: EWG-13A, EWG-13B, and EWG-20 (LWD placement); EWG-19A, EWG-22, and EWG-89 (geomorphic treatments for creation of riparian habitat); EWG-16A and EWG-16B (enhancement or creation of side channel habitat); and EWG-61 and EWG-66 (developing flow management strategies).

Recommendations:
Incremental or small-scale riparian enhancement or restoration measures are not likely to provide substantial benefits to the Feather River corridor. Experience has shown that local restoration and enhancement projects also have high probabilities of failure if they do not fully account for ecological and geomorphic constraints. Therefore, a comprehensive riparian enhancement program for the entire Feather River corridor would be required. The scope of such and effort would be beyond the scope of the FERC boundary and beyond DWR's obligation for protection, mitigation or enhancement.

In order to implement a large-scale riparian enhancement or restoration program, a number of small-scale resource actions would likely be developed into a synergistic approach. Therefore, Resource Actions EWG-17 and EWG-51 have been recommended as a Category 4. It is also suggested that EWG 16a and EWG 16b include specific consideration of establishing and evaluation small efforts to create or sustain riparian canopy adjacent to side-channel improvements or creation. This would require assessments of current conditions throughout the study area, prioritization and identification of restoration and enhancement needs, and implementation of a project over time (potentially a long time) that will result in a more properly functioning riparian system.

Resource Action: EWG-19A **Task Force Recommendation Category:** 2

MODIFY OR RECONSTRUCT BENCHES IN THE FEATHER RIVER CHANNEL TO ENHANCE SPAWNING AND REARING HABITAT

Date of Field Evaluation: No field evaluation has been conducted

PM&E Evaluation Team: Richard Harris, Koll Buer, and Bruce Ross

Proposed PM&E:
To modify existing floodplain deposits or build vegetated "benches" at various stage elevations in the lower Feather River (i.e., near Verona) to enhance splittail spawning habitat and Chinook salmon rearing habitat.

Related PM&Es:
- EWG-22 that would attempt to improve connectivity of the river with its floodplain in the lower Feather River by setting levees back.
- EWG-16A and EWG-16B, which proposes enhancement of existing, or creation of new side channel habitat in the lower Feather River.
- EWG-17 and EWG-51 which is intended to enhance or restore riparian habitat.

Potential Environmental Benefits:
As proposed, this measure will increase the topographic diversity of the lower Feather River within the confines of existing levees. That would be achieved through either the modification of existing geomorphic surfaces or through the creation of new ones. Increased topographic diversity in turn, is expected to increase habitat diversity and benefit targeted fish species, including splittail and Chinook salmon. It could also potentially serve to improve conditions for the recruitment and development of riparian vegetation. Improving riparian conditions would benefit wildlife that depend on this type of habitat.

Conditions in the Proposed PM&E Implementation Area:
The lower Feather River (especially below Gridley) is presently incised well below its former floodplain (10-25 feet). Studies conducted by DWR indicate that the Rosgen classification for the lower Feather River is “entrenched, F channel type.” Prior to the placement of levees, hydraulic mining, and subsequent down cutting, the lower Feather River was a meandering C channel type, comparable to the Sacramento River and other streams draining to the Central Valley. At intervals of approximately 1-2 years it would have experienced overbank flooding onto its adjacent floodplain. At the present time, only floods in excess of approximately 50,000 cubic feet per second (cfs) would cause flooding out of the entrenched channel. These have occurred about a dozen times over the past 40 years. High magnitude flooding events (>100,000 cfs) have occurred three times, in 1965, 1986 and 1997.

Alluvial streams typically have well-developed sequences of alternating bars. Currently, the lower Feather River generally does not possess these attributes, or many of the other characteristics of an alluvial river in dynamic equilibrium.

Under SP-G2, the geomorphic reaches in the lower Feather River have been categorized. From Feather River Mile (RM) 59 (Thermalito) to RM 0 (Sacramento confluence) eight reaches were defined. Two sections (RM 39 to RM 54 and RM 34 to RM 35.5) presently have a high degree of instream geomorphic diversity (i.e., islands, bars). They also have moderate to high sinuosity with well-developed point bars. The substrate in RM 39 to RM 54 is gravel, and at RM 34 to RM 35.5, it is sand and gravel. In both areas, levees are well set back from the stream on at least one side of the channel.

For the remainder of the lower Feather River, the channel cross section is roughly trapezoidal, the channel is relatively wide, and there are relatively few floodplain surfaces. Those surfaces that do exist are mostly sand substrate, and the channel bottom itself is predominately heavy clay, which may not be suitable for salmonid rearing habitat or splittail spawning habitat.

Most existing deposits within the incised channel are inundated by flows greater than 10,000 cfs. During the summer months flows are relatively high due to water supply releases for downstream uses. For example, under current project operations, median daily flows in August are about 6,000 cfs. During most winter months, existing impaired (i.e., operational) flows exceed estimated unimpaired flows in the lower Feather River. It is only during the spring runoff season that impaired flows are lower than unimpaired flows (i.e., when the reservoir is filling). Thus, the impaired flow regime does not resemble the unimpaired regime either in timing, magnitude, or duration of peak flows. This has implications for both the design and possible functioning of floodplain surfaces that might be created in the lower Feather River under this Resource Action (see discussion under Design Considerations).

Design Considerations and Evaluation:
Because of the current conditions in the lower Feather River, this Resource Action would represent a complex engineering approach to habitat creation. Creating new floodplain surfaces or benches in places with little or no topographic diversity would be potentially risky. In such places there probably would not be sufficient material available within the channel to create new surfaces, and therefore materials would have to be imported.

Because of those issues, it would be advantageous to develop any proposals for geomorphic restoration for places that already have some desired features. At RM 34 to RM 35.5, existing point bars could be modified to improve their exposure to flooding (assuming an appropriate flow regime, see below). From RM 39 to RM 54 there is not only a relatively high degree of topographic diversity, but the substrate is gravel and levees are well set back in most locations. These areas initially seem to be places where geomorphic restoration could be feasibly undertaken without requiring levee set backs.

One additional area for geomorphic restoration would be RM 0 to RM 9. Although there is little permanent geomorphic diversity in this area (bed materials consist primarily of sand waves),

the levees are set back due to Sutter Bypass. However, any proposal for this area should receive detailed study due to the inherently unstable geomorphology.

If new benches were created or floodplain surfaces modified, they would require bank protection to prevent erosion. The substrate available within the lower Feather River consists primarily of sand, silt and clay. Even at RM 39 to RM 54 or 34 to RM 35.5, the substrate is gravel or gravel and sand. Bank protection could be accomplished through the addition of rock (i.e., rip-rap) imported from outside the area or with bioengineering approaches (willow mattresses, etc).

It is assumed that the modified surfaces or benches would be constructed at elevations corresponding to different magnitudes of flow, simulating a natural floodplain setting. It is conceivable that stage-discharge relationships corresponding to unimpaired flood flows could be developed and used to design the geomorphic restoration. However, the existing flow regime does not currently resemble the unimpaired hydrograph. Therefore, EWG-19A would have to be designed in conjunction with other proposed Resource Actions to modify the existing flow regime.

If the benches and flow regime approximated a natural condition, it would probably represent a scaled-down version of the former alluvial system present in the lower Feather River. That is, it would be an alluvial system within the entrenched channel operating on an impaired natural flow regime. Although not difficult to envision, it would likely prove difficult to design as a self-regulating system. Probably the most challenging aspect would be estimating and negotiating the prescribed flow regime.

It should be noted that the IHA analysis conducted under SP-G2 provides a basis for estimating the departure of the regulated (impaired) flow regime from the natural (unimpaired) flow regime. It also provides the basis for developing a scaled-down impaired natural flow regime that would be appropriate for this Resource Action.

It is possible that side channel habitat enhancement or creation in the lower Feather River (EWG-16A and EWG-16B) could be designed in conjunction with this Resource Action. In any event, precautions against potential fish stranding on created surfaces (or in side channels) would be required. Therefore, consideration should be given to flow ramping, as well as the discharges required to flood the benches.

The proposed Resource Action would include planting or otherwise establishing vegetation on the benches. This aspect of the Resource Action is best coordinated with EWG-17 and/or EWG-51, which deals with riparian vegetation enhancement. It is assumed that the vegetation on the benches would attempt to simulate a natural riparian successional pattern. The vegetation on different geomorphic surfaces would correspond to flood exposure. Reference conditions would be needed and these will probably be developed if a comprehensive approach to riparian vegetation enhancement and restoration is pursued. For EWG-19A, specific items to consider include erosion control, desired future riparian vegetation, control of exotics, and relationships between flow and vegetation.

The effects of the geomorphic restoration on downstream and upstream geomorphic processes would need to be evaluated. If the emphasis were on modifying surfaces that already exist, the potential effects would probably be relatively insignificant. If entirely new surfaces were created, they would change flows and geomorphic processes in an already unstable system. Therefore, the latter would probably be more risky and would likely require more detailed evaluation.

Another major issue to consider in the design of this Resource Action would be potential response to extreme peak flow events. During events such as the 1997 flood there could be massive erosion on the created or modified geomorphic surfaces.

Measures of effectiveness of this PM&E could include mapping of created surfaces and associated vegetation and population surveys of targeted fish species.

Recommendations:
This is a conceptually appealing proposal but it requires much more thought if it is to be further planned and ultimately implemented. It is probably best to combine EWG-19A with EWG-22 (proposing levee setbacks) and/or EWG-16A and EWG-16B (proposing side channel creation and enhancement) and approach the question of geomorphic restoration in the lower Feather River in a more general way. Even better would be combining geomorphic restoration with riparian restoration and looking at both together. This would facilitate evaluation of alternative flow regimes that would support restoration proposals. However, even before all that, the approach to restoration needs to be clarified. Is the intention to engineer restoration or to restore processes so that the stream naturally restores itself? There are examples of both approaches to stream restoration in California and it would be instructive to learn more about what has worked (and where) before deciding on specific restoration measures.

Resource Action: EWG-22 **Task Force Recommendation Category:** 2

IMPROVE CONNECTIVITY OF FLOODPLAIN TO THE FEATHER RIVER THROUGH LEVEE SETBACKS

Date of Field Evaluation: No field evaluation has been conducted.

PM&E Evaluation Team: Richard Harris, Koll Buer, and Bruce Ross

Proposed PM&E:
Increase connectivity between the river channel and adjacent floodplain habitats (including low-elevation terraces) in the lower Feather River by setting back levees to create seasonal habitats for Chinook salmon, splittail, and steelhead.

Related PM&Es:
- EWG-19A, measures aimed at modifying or creating floodplains in the lower Feather River (EWG-19A).
- EWG-16A and EWG-16B, measures aimed at enhancing or creating side channel habitats in the lower Feather River.

Potential Environmental Benefits:
The benefits of increasing connectivity between the river and its floodplain would include improvements in fish habitats and increased availability of land for recruitment and development of riparian vegetation. Improved riparian vegetation conditions would in turn, benefit wildlife that use riparian habitats.

Conditions in the Proposed PM&E Implementation Area:
The Resource Action (PM&E) has been proposed for the lower Feather River. No further specification has been provided at this time. It is assumed that levee setbacks could be implemented in locations where there are the following prerequisites:

- Potential for reconnecting the floodplain to the stream at moderate flows solely by levee removal or setback.
- Available land.
- Potential for enhancing existing floodplain surfaces (or creating new ones).
- Limited potential for increasing flood hazards.

The lower Feather River (especially below Gridley) is presently incised well below its former floodplain (10-25 feet). Studies conducted by DWR indicate that the Rosgen classification for the lower Feather River is “entrenched, F channel type.” Prior to the placement of levees, hydraulic mining, and subsequent down cutting, the lower Feather River was a meandering C channel type, comparable to the Sacramento River and other streams draining to the Central Valley. At intervals of approximately 1-2 years it would have experienced overbank flooding onto its adjacent floodplain. At the present

time, only floods in excess of approximately 50,000 cubic feet per second (cfs) would cause flooding out of the entrenched channel. These have occurred about a dozen times over the past 40 years. High magnitude flooding events (>100,000 cfs) have occurred three times, in 1965, 1986 and 1997.

The levee system that protects land adjacent to the river from flooding is not uniformly close to the stream. In some locations, for example, in the developed areas of the cities of Oroville and Yuba City, levees do completely cut off the stream from its floodplain. In other locations, levees may be absent altogether from one or the other side of the river (e.g., Sutter Bypass). There are a number of places, especially on point bars, where levees are set back over 1,000 feet and agricultural uses are occurring within the levee boundaries.

The levee system below Thermalito is part of the Sacramento River Flood Protection Project and any proposals to modify the system would have to be approved by the USACE and overcome various institutional barriers inherent in maintaining flood protection.

The primary constraints to connecting the Feather River to its former floodplain are the degree of incision and the flow regime itself that prevents higher magnitude flooding events. Levees are a constraint only in specific places in the lower Feather River. Where they are a constraint, flood hazard considerations may be paramount.

Most existing deposits within the incised channel are inundated by flows greater than 10,000 cfs. During the summer months flows are relatively high due to water supply releases for downstream uses. For example, under current project operations, median daily flows in August are about 6,000 cfs. During most winter months, existing impaired (i.e., operational) flows exceed estimated unimpaired flows in the lower Feather River. It is only during the spring runoff season that impaired flows are lower than unimpaired flows (i.e., when the reservoir is filling). Thus, the impaired flow regime does not resemble the unimpaired regime either in timing, magnitude, or duration of peak flows.

Design Considerations and Evaluation:
Under the current conditions (including the current regulated flow regime), levee setbacks would not generally be expected to achieve significant benefits. Removing levees in and of itself would not reconnect the stream to its floodplain. It would be more appropriate to consider levee set backs along with geomorphic restoration (EWG-19A), side channel enhancement and/or creation (EWG-16A and EWG-16B), and change in flow regime together as a comprehensive approach to improving the functioning of the lower Feather River. However, if EWG-22 is to be further evaluated independently, several questions would need to be answered:

- *Where should levee setbacks be placed to maximize their benefits?* There are some specific locations that we have not yet identified where levees may be the main constraint on floodplain connectivity. These could be considered for project

implementation. However, the ecological benefit of these projects is likely to be very localized.

- *Are lands available for levee setbacks in the appropriate locations?* Assuming that some locations are suitable, landowner willingness would have to be determined.
- *Would levee setbacks provide any benefits under the current regulated flow regime?* As previously discussed, at the present time, the main floodplain is well above the stream and only inundated by extreme peak flows.
- *What flow regime would maximize benefits?* If any sites seem appropriate for levee removal, there would need to be an analysis of what streamflows would be necessary to maximize their ecological benefits.
- *How do any proposed setbacks adhere to the Comprehensive Study's Guiding Principles?* The Comprehensive Study has outlined a structure by which the flood protection project may be modified.

Recommendations:

Preliminary evaluation of this Resource Action indicates that alone it would probably provide relatively few enhancements to the lower Feather River, and more importantly, the limited enhancements may not be possible to achieve. To achieve its goal of increasing connectivity of the floodplain to the lower Feather River for the benefit of creating and enhancing fish habitat, this Resource Action should be combined with other Resource Actions (i.e., EWG-16A/B, EWG-17) if an aggressive habitat construction approach is to be implemented in the lower Feather River. However, if some site-specific benefits are desired from levee setbacks unaccompanied by other Resource Actions, additional information would be needed to identify appropriate and available sites.

In general, EWG-22 does not seem very promising and even though it is presently a Category 2 Resource Action (waiting for more information), it seems likely that with additional evaluation that it will be recommended for Category 4 (no further action).

Resource Action: EWG-89 **Task Force Recommendation Category:** 2

PROPOSED SPAWNING HABITAT ENHANCEMENT BY CREATING LEVEE SETBACKS

Date of Field Evaluation: June 11, 2003

Field Evaluation Team: Richard Harris, Philip Unger, Jason Kindopp, and Brad Cavallo

Proposed PM&E: Create levee setbacks to increase meandering nature of river and improve gravel composition in critical spawning reaches of the Low Flow Channel (LFC) of the Feather River.

Goals Include:
Increase meandering nature of river and improve gravel composition in critical spawning reaches of the LFC. However, it should be noted that the LFC is not naturally a meandering system (Koll Buer, personal communication). It would be more accurate to state that the goal of this Resource Action is to increase gravel recruitment by allowing the stream to access and erode bank and floodplain deposits. Other goal would also be to increase inundatable floodplain habitat to increase quantities of fish spawning habitat.

Related PM&Es:

- EWG-22, that would attempt to improve connectivity of the river with its floodplain in the lower Feather River by setting levees back.
- EWG-19A, that would modify or create "benches" or floodplain surfaces in the lower Feather River.
- EWG-16A and EWG-16B, which proposes enhancement of existing, or creation of new side channel habitat in the lower Feather River.
- EWG-92, that would improve spawning habitat in the low flow reach by direct placement of gravels.

Potential Environmental Benefits:
Most of the Feather River's LFC is highly constrained by levees. As a result of this and other factors, natural fluvial geomorphic processes (channel migration, gravel recruitment, avulsions, etc.) have been altered, and may have a negative impact on rearing habitat and spawning gravel quality. Geomorphically complex and active habitats are most closely associated with gradient changes and broad, unconfined active channel areas. Such habitats, particularly reaches with multiple channels, are typically the most productive rearing habitat for juvenile salmonids in large low gradient rivers like the lower Feather River.

The premise of this Resource Action is that setting levees back from their current positions would allow the river to erode its banks and floodplain. If the composition of the banks and floodplain consists of suitably sized gravels, and if the recruited material

finds its way to spawning riffles, there could be improvements in salmonid spawning habitat quality and quantity. Creating levee setbacks would also provide connectivity with larger portions of the active channel and floodplains which are currently cut-off by levees. Increased floodplain area in turn, would increase the potential area of riparian vegetation. Allowing the river to meander could also increase the supply of sediment to the river. If this sediment is of the appropriate sizes, it could potentially help to replenish depleted spawning gravels. In addition, levee setbacks created in the LFC could improve wetlands, habitat for wildlife species, and enhance the aesthetic value of the river corridor.

Conditions in the Proposed PM&E Implementation Area:
Habitat for anadromous salmonids in the LFC has been affected by the disruption of natural geomorphic processes due to myriad causes (hydraulic mining, land uses, levees), by the regulation of flow and by the presence of the dam creating Lake Oroville. The dam blocks sediment recruitment from the upstream basin. Levees, and more specifically, bank armoring, prevent gravel recruitment from banks, abandoned channels, mine tailings and floodplains.

Regulated flows are of sufficient magnitude to winnow gravels that do exist from spawning riffles resulting in armoring of the remaining substrate. Much of the stream bed substrate in the LFC is composed of larger gravels and cobbles too large for construction of spawning redds by salmon and steelhead. Despite these constraints, the LFC is by far the most important section of the river for salmon and steelhead spawning.

Most of the LFC is closely bounded by a complex system of levees, which include typically older levees, some of which are the responsibility of DWR. The effects of the levees are two-fold. Their principal impact is to disconnect the river from its floodplain thereby preventing overbank flooding. A secondary impact is to prevent the stream from accessing alluvial deposits that could serve as sediment sources for gravel recruitment. Although specific information for the LFC is not yet available, most of the levees there are armored with cobbles that prevent erosion and lateral movement of the stream. Levees surrounding the Oroville Wildlife Area (OWA) have experienced at least two levee breaks due to past floods (at River Mile (RM) 61 and RM 63).

In addition to bank or levee erodibility, other factors that affect erosion are the volume and velocity of streamflow. Streamflow is highly regulated in LFC. Consequently, there are rarely any floods of sufficient magnitude to initiate bank erosion. Only extreme floods (i.e., >100,000 cfs), such as those that occurred in 1965, 1986 and 1997 affect the LFC. During one of those events (either 1965 or 1986) the levee breaks at the OWA occurred. However, major widening of the channel did not occur, probably because of bank armoring.

Another effect of levees, particularly those that are well-protected against erosion, is to constrict flood flows thus increasing flood velocities and their potential to cause

downstream erosion. Virtually the entire LFC is protected by closely set levees. That is not the case further downstream where the distance between levees is wider.

Because of water temperature constraints, the LFC is currently the only portion of the Feather River below Oroville dam suitable for year-around rearing of juvenile salmonids. Habitat with suitable depth, cover, and flow velocity conditions for rearing salmonids is, however, limited. Rearing habitat in the LFC is particularly important for steelhead, which generally rear for several months to a year or more before emigrating to sea. Most Feather River Chinook salmon begin their emigration within a month or two of emerging from their redds.

In summary, the LFC is extremely important for salmonid spawning and rearing. However, both spawning and rearing habitat are limited. The main factors currently contributing to the limitations on habitat are the presence of the dam (preventing downstream sediment delivery), the regulated flow regime and to some extent, the presence of levees that confine the channel and prevent development of habitat complexity.

Design Considerations and Evaluation:

The flow regime of the Feather River is the most important design consideration affecting the success of levee setbacks. The Oroville Project is currently operated to maintain relatively low, uniform flows through the LFC. High flows generally occur only during periods of extreme runoff. Creating levee setbacks under these flow conditions would have only limited value because the floodplain would only occasionally receive the high flows necessary to create productive habitat and recruit good quality spawning gravels. In addition, there is also a potential concern that setting back the levees may allow the channel to widen and may not increase the meandering, but rather, it might reduce the ability of the stream to do work. Furthermore, an increased surface area could potentially increase the water temperature of the lower Feather River.

Artificial side channel habitat and spawning habitat channels could be created in some floodplain areas (as discussed in the narrative report for EWG-16A), but such habitat could potentially have relatively high maintenance costs and may be less productive than side channel habitat naturally created by periodic floodwaters. Project operations (related to releases from Oroville Dam) could be altered to have the LFC, as the entire Feather River, to more closely mimic a natural flow regime, with more frequent periods of high flows, including periodic flood events. Such a flow regime combined with levee setbacks would probably result in much more rearing and spawning habitat for salmon and steelhead. Some contouring (or engineered structures) of floodplain land could be necessary prior to flooding to eliminate areas with potential for stranding redds and juveniles. Note: The costs associated with construction and/or re-engineering levees could be very high, and should be considered along with additional related Resource Actions. Based on discussions with DWR personnel, two potentially suitable locations include: 1) the west side of the Feather River (River Mile (RM) 59 to RM 62 and RM 63

to RM 64); and 2) the east side of the Feather River (RM 50 to RM 59). The State reportedly owns the land for each of the above options.

In evaluating flow regimes that would be supportive of this measure, it would be necessary to develop stage-discharge relationships that could be used to evaluate post-levee removal floodplain inundation. Fluvial 12 is calibrated for use in the LFC and could be used to evaluate levee removal and flow management alternatives. Any flow management proposal needs to consider several factors including scheduling of flow to provide rearing habitat when it is most needed by juvenile salmonids. Another issue that would need to be addressed would be prevention of fish stranding. If flow in the LFC is greater than 2,500 cfs any time during October 15 through November 30, the 1983 agreement between the California Department of Fish & Game (DFG) and the California Division of Water Resources (DWR), requires the Oroville Project to provide that minimum flow (less 500 cfs) until the following March. This agreement is designed to minimize dewatering of redds and stranding juveniles in ponds or temporarily inundated channels.

Since the primary objective of this measure is to recruit spawning gravel, then another consideration would be whether or not the areas accessed by the stream due to levee set backs actually have gravel of appropriate sizes. The ability of different flows to move the gravels into the main channel and the likelihood that the gravel that is recruited would be retained there would also require evaluation. There is also some concern that deposits accessed by the stream might have some level of soil contaminants.

A number of exotic plant species inhabit the OWA and other former floodplain areas in the LFC corridor. Flooding of these areas could promote dispersal of the exotics to downstream areas currently free of these species. Mitigation against this would have to be incorporated into the measure.

Creating levee setbacks would likely entail major earthmoving activities. To minimize water quality problems associated with such activities, particularly turbidity and sedimentation, the work should be scheduled for summer, when the annual rainfall is lowest in the basin. A July through mid-August timeframe for earthmoving activities would probably present the least adverse effects on water quality on sensitive life stages of salmon and steelhead.

A measurement of success of this PM&E would be newly created spawning and rearing habitats and their use by salmonids. Success would ultimately be measured by long-term salmon and steelhead escapement levels, although it might not be possible to determine the relative contribution a particular resource action enhancement measure to any increases in escapement.

Recommendations:
This measure would require complex engineering and environmental design analysis in relation to its main objective. There are several sources of uncertainty regarding this

measure: 1) the suitability of potential locations for levee removal; 2) the required permitting and environmental documentation; 3) the key importance of the flow regime; 4) the potential for lands accessed by flows to produce the desired gravels; 5) the retention of recruited gravels at the appropriate places in the LFC (i.e., spawning riffles); and 6) the performance of the measure during extreme flooding events.

Perhaps the principal issue with this measure is whether or not it is a good way to achieve spawning gravel enhancement. In levee set back projects proposed for other river systems (e.g., Sacramento, Cosumnes, Mokelumne, Truckee) the main objective has been to increase floodplain area and associated riparian habitat. This is probably a more workable objective for a levee set back project in the low flow reach.

Therefore, this Resource Action should be evaluated for effectiveness in comparison to or in combination with more direct measures for spawning gravel enhancement such as EWG-92. Also, as noted in the narrative report for EWG-94, there is a possibility to both enhance ponds in the OWA and produce gravel for direct placement. That Resource Action, which is incorporated into EWG-16A, EWG-16B, EWG-22, EWG-89, and/or EWG-92, would involve excavating ponds to increase their depth and water surface area. The excavated material could then be used for direct placement at spawning riffles.

Combining levee set backs with direct gravel placement would potentially have the effect of enhancing spawning riffle substrate suitability. The widened cross section and reduced stream power would increase the possibilities for gravel retention. This combined measure would not necessarily require major changes to flow management, although potential effects on stream temperature would have to be considered.

It seems reasonable that after further review that this Resource Action might be reclassified from Category 2 (waiting for more information) to Category 4 (no further action).

Resource Action: EWG-92	**Task Force Recommendation Category:** 2
Resource Action: EWG-91	**Task Force Recommendation Category:** 4

PROPOSED GRAVEL REPLACEMENT FOR ENHANCEMENT OF SALMONID SPAWNING AREAS IN THE LOW FLOW CHANNEL

Task Force Recommendation Category: EWG-91 and EWG-92 have been combined into one PM&E (Resource Action EWG-92). Therefore, EWG-92 has been recommended for *Category 2*, while EWG-91 has been recommended for *Category 4.*

Date of Field Evaluation: No field investigation has been conducted; however, detailed discussions occurred at the DWR-Red Bluff facility on July 28, 2003.

Evaluation Team: Richard Harris, Koll Buer, and Bruce Ross

Proposed PM&E:
Supplement the low flow channel with gravel in the vicinity of spawning riffles, if the ongoing study plan (SP-G2) indicates these areas are found to be of poor quality for spawning. The ultimate goal is to increase the availability of spawning habitat for anadromous salmonids.

Related PM&Es:
- EWG-16A and EWG-16B, which proposes enhancement of existing, or creation of new side channel habitat in the lower Feather River.
- EWG-19A, that would modify or create “benches” or floodplain surfaces in the lower Feather River.
- EWG-22, that would attempt to improve connectivity of the river with its floodplain in the lower Feather River by setting levees back.
- EW-89, that would set back levees to increase meandering nature of river and improve gravel composition in critical spawning reaches of the low-flow reach.

Potential Environmental Benefits:
The benefits of enhancing spawning habitat would include increased production of anadromous salmonids (salmon and steelhead).

Conditions in the Proposed PM&E Implementation Area:
Habitat for anadromous salmonids in the low flow reach of the Feather River has been affected by the disruption of natural geomorphic processes due to a myriad of causes including: historic hydraulic mining, historic and current land uses, the construction and maintenance of flood control levees, by the regulation of flow in the river, and by the presence of the dam creating Lake Oroville. The dam blocks sediment recruitment from the upstream basin from flowing into the lower Feather River. Levees, and more specifically, bank armoring, prevent gravel recruitment from banks, abandoned channels, mine tailings and floodplains. Periodic peak flows are of sufficient magnitude

to winnow smaller-sized gravels from spawning riffles resulting in armoring of the remaining substrate. Much of the stream bed substrate in the low flow channel is composed of larger gravels and cobbles, which are too large for construction of spawning redds by the salmon and steelhead. Despite these constraints, the low flow channel is by far the most important section of the river for salmon and steelhead spawning.

Design Considerations and Evaluation:

Placement of gravel in the low flow reach could be accomplished in one of three ways:

1. Gravel could be introduced into the system in the vicinity of the fish barrier dam and allowed to migrate downstream.
2. Gravel could be directly placed at spawning riffles.
3. Gravel could be placed in the vicinity of naturally eroding banks, from where it would be transported downstream.

If options (1) or (2) were selected, water quality considerations would require that the gravels be washed before introducing them to the stream in order to prevent increased turbidity. Placing the gravels near naturally eroding banks (Option 3), would eliminate the necessity for washing the gravel, thereby potentially reduce costs to implement the Resource Action.

It may be more efficient to place gravels directly at targeted riffles. However, either introducing gravels at the top of the reach or allowing the gravels to erode from bank positions would probably still have positive effects. Additional information would be needed to determine the best approach for gravel supplementation. Gravel supplementation programs have been implemented elsewhere including the Sacramento River near Redding, the Mokelumne River below Camanche Dam, the Merced River below Crocker-Huffman Dam, and other rivers throughout the Central Valley. Evaluations conducted by those efforts can help choose the optimal approach for the Feather River.

Under the current flow regime (regulated flows of 600 cfs), particles the size of spawning gravels are not flushed from the low flow channel. Spawning gravel transport occurs when periodic peak flows are between 30,000 and 60,000 cfs. Flows >50,000 cfs have occurred approximately 12 times since closure of the dam. Consequently, gravel placements would have to be repeated after peak flow events in order to maintain the benefits of this measure. Some changes to the flow regime (e.g., periodic pulsed flows) may be necessary to transport gravel to riffles from placement sites

If gravel is supplemented in the low flow reach and is moved downstream by peak flows, this could have positive downstream effects as far as Gridley. The gravel transported downstream could contribute to creation of geomorphic surfaces and point bar development. This would partly restore natural sediment transport processes in the river.

Data exist from SP-G2 on the amount of gravel that was transported in the Feather River prior to closure of the dam. These data could be used to design a gravel supplementation project that would be commensurate in quantity with the impaired flow regime.

Gravel placement could be benefited by the use of instream structures and LWD as proposed in EWG-13A and 13B. Instream structures placed at riffles could assist in retaining gravel and potentially enlarging spawning riffles.

Other approaches could be introduced to increase the availability of spawning habitat. For example, for years Moe's Ditch (near the hatchery) was managed to provide spawning habitat by gravel placement, however, this also proved to be only a temporary benefit. Each year the gravel migrated to the mouth of the ditch and had to be re-graded. That practice has been discontinued, and at the present time, Moe's Ditch does not provide any spawning habitat. Similar projects (i.e., artificial channels), while potentially only temporary, could be considered to provide additional spawning habitat.

Recommendations:
This measure should be considered as a potentially viable solution for the lack of suitable spawning habitat in the low flow reach. However, any approach to supplement the stream channel with gravel would, if not done in conjunction with measures to transport and retain the gravels at the spawning areas, potentially provide only temporary benefits. Therefore, it should be considered in conjunction with Resource Actions designed to enhance gravel retention at targeted riffles (i.e. EWG 13A and 13B. Further study would be required to determine: 1) what quantities of gravel should be placed; 2) where the gravel should be placed; 3) what modifications to the flow regime may be required to make the Resource Action work; 4) what, if any, instream structures should be used (and where) to enhance retention at spawning riffles; and 5) the feasibility of combining gravel placement with pond enhancement in the Oroville Wildlife Area.

Resource Action: EWG-94 **Task Force Recommendation Category:** 4

PM&E Evaluation Team: Richard Harris, Koll Buer and Bruce Ross

Proposed PM&E:
The Resource Action proposes to increase floodplain connectivity between the mainstream Feather River and the Oroville Wildlife Area (OWA) to increase inflow to selected OWA ponds during higher flows. The benefits of increasing the area and depth of ponds by engineered recharge in the OWA would potentially include enhanced fish production, increased area of riparian and wetland vegetation, and increased habitat for water or riparian/wetland-dependent wildlife.

There are many ponds of various sizes and depths in the OWA. Some of these were intentionally created (engineered), while others were caused by historic mining (hydraulic) activities. The water levels in these ponds are primarily influenced by groundwater, which in turn, is closely related to the stage in the Feather River. At the present time, there are two weirs in the levees surrounding the OWA that permit flows to enter the OWA from the Feather River, however, both of these weirs only operate at very high flows.

Related PM&Es:
There are a number of measures that are either similar to or potentially complementary to this PM&E. They include: EWG-79 and EWG-80 (increase the fisheries, riparian and wildlife values of the OWA); EWG-19A, EWG-22, and EWG-89 (geomorphic treatments for creation of riparian habitat); EWG-16A and EWG-16B, (enhancement or creation of side channel habitat).

Recommendations:
There are at least two options for improving inflow to OWA ponds: 1) modify existing weirs to increase their capacity to divert flows at lower levels of streamflow; or 2) remove the levee (see narrative report for EWG-89). Of the two options to increase the flows between the ponds and the main Feather River channel, removing levees (Option 2) would involve the most extensive engineering design work and construction. Enlarging or modifying the existing weirs (Option 1) would require a slightly less complex engineering design.

If flow diversion to OWA were increased during normal streamflow periods, it would reduce streamflow in the lower Feather River, which could result in elevated temperatures in the river. If either increasing weir capacities or removing levees were pursued, it is unlikely that flow diversions would be permitted during normal streamflow conditions.

This Resource Action is to be incorporated into EWG-16A, EWG-16B, EWG-22, and/or EWG-89. Therefore, it has been recommended as a Category 4.